

A Geminoid as Lecturer

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Abstract. In this paper we report our findings from an experiment with the tele-operated android Geminoid-DK. The geminoid took up the role of a university lecturer and delivered a 45 minute lecture in front of 150 freshmen students at Aalborg University. While considering the role of the geminoid in this educational context, we report results relating to large-room teaching, as well as gender differences in the perception of the robot.

Keywords: Human-robot-interaction, Geminoid-DK, gender differences, case study.

1 Introduction

Placing androids in real life situations offers special conditions to learn about human robot communication. This is important for two reasons. In the first place, we are eventually aiming at being able to place androids in various real life contexts and to let them perform complex tasks. In order to approach a situation where this is feasible, many small scale tests must be conducted to learn about the conditions for such communications to be successful. Actual use in the physical real often offers surprises with respect to both perception and practical implication. In the second place, real life experiments outside the controlled atmosphere of the research lab expose androids to different kinds of reactions. This is particularly true of interactions that involve more people than can be accommodated in the lab. As part of an ongoing investigation into the success criteria for communication involving at least one android, we decided to devise an experiment in which the Geminoid-DK took up the role as a university lecturer. In setting up the experiment, we aimed at creating as realistic a situation as possible. In section 2 of this paper, we present our conceptual deliberations regarding the experiment along with details of the technical setup. In sections 3-5 we report our findings, and in section 6 we draw attention to the need for further research conducted in this area.

1.1 Simulation and Situation

The concept of the geminoid robots, original conceived by Hiroshi Ishiguro [1], hinges on the idea that the android should look exactly as the human original in whatever respect it is possible. Physical likeness between the two is a central part of the research paradigm, and as such, the geminoid research programs are concerned

with simulations of the human original. This is true both with respect to the physical appearance of the robot exterior, and with respect to movements of the face and body. Personal traits and idiosyncrasies are considered at every stage of the design process, from the molding of body parts to programming and control of patterns of movement. Much attention is given to details in order for the geminoid to appear as an exact copy of the human original. One goal of the simulation aspect of geminoid research is to present the android in such a manner that it becomes a believable substitute for the human. And while we are still far from reaching this ideal on the grand scale of real life, important progress has been made in order to make a persuasive appearance of these geminoids. But this research is not only about simulation. We maintain that it is equally important to consider the situation in which the geminoid is supposed to function. In consequence, the success criteria for well-performed geminoid interactions may well change from situation to situation. What might work in an auditorium with 150 people may produce serious side effects in a face to face situation involving only two or three people.

1.2 Similar Investigations

The study of robots used in educational contexts is a quite new research field, but it has been described in the following works that are mostly carried out in elementary schools. In Japan, Kanda et. al. have exposed the humanoid - but somewhat mechanical Robovie to Japanese students in the first and sixth grade in elementary school to measure the effects of a robot in English language learning. The students test score in English didn't improve significant due to this intervention, but the students who showed interest in the robot as a teacher had an elevated English score, which indicated that robot-aided English learning can have an effect on young students' motivation [2]. Korean researchers from Yujin Robotics have used the humanoid IROBI to prove their hypothesis that robot-aided learning improves children's concentration, interest and academic achievement [3]. In Korea, a teaching assisting robot named TIRO has also been used in research in English language learning in a third grade in elementary school, playing with the children. This study found that the children liked robot services for personal relationship in class, and teachers found the robot useful because it relieved them in their work [4].

The most similar investigation compared to our Geminoid-DK study is made with the Japanese android SAYA [5] who can both conduct lectures by tele-operation and observe student's behavior. The SAYA research was conducted in both elementary school and at a university to estimate any age-dependent differences of its effectiveness. The conclusion was that the students in elementary school accepted the remote class support system with SAYA more easily than university students [6,7,8].

2 Experiment Setup

In order to create an atmosphere as realistic as possible, we decided to conduct the experiment with a group of freshmen students, with no prior personal experience with the lecturer. The lecture was given during the first month of the semester, and was part of an introductory program, intended to present the new students with

information about core perspectives on Human Centered Informatics, as it is taught at Aalborg University in Northern Denmark. This means that this lecture in content and form was part of the regular first year course, and as such, held no specific surprises with respect to scope, intended learning outcome, or style. It was in other words, an ordinary lecture, besides the fact that the lecturer this morning was a tele-operated robot. Before the lecture, the Geminoid was placed in the auditorium, behind a desk with laptops and other typical teaching accessories. The operator was located in another part of the same building, and controlling the robot and other equipments via wireless network. At the same time, a researcher sat among the audience, partly to correct and intervene should something unexpected happen, and partly to observe the reactions of the audience first hand. The lecture was a standard 2 x 45 minute affair, and during the second lecture, both the geminoid and the original were present. Thus, part of the second lecture was structured as a conversation about the experiment in the first lecture.

2.1 Technical Setup

The movements of the Geminoid, visible to the audience, are a mixture of software components from different sources. A set of basic movements such as minor movements of the eyes, breathing, and blinking, are sequenced in advanced and delivered from a laptop also carrying the geminoid servers. Movements of the lips are synchronized from the voice input of the operator, as is movement of the head and direction of gaze. This means that the operator from a distance takes direct control over the main parts of the movements. See [1] for a technical description. The voice of the operator is captured from the control room sent over IP to the auditorium where it is analyzed in order to generate movements of the lips of the robot. From the local laptop, the sound signal is then passed on to a speaker behind the robot where a microphone picks up the sound and amplifies it through the ordinary PA system of the lecture room. The result is that the voice of the lecturer is heard from room speakers mounted on the ceiling, as well as from the direction of the robot. A PowerPoint presentation containing roughly 60 slides were delivered to two projector screens behind the geminoid. The slideshow was also remotely controlled by the operator. Again, this allows for improvisations and direct interaction with the students.

In order to navigate and interact with the audience, the lecture room was equipped with cameras and microphones, allowing the operator to visually orient himself in the room, and to respond to questions and comments from the audience. We used standard surveillance cameras with built-in microphones that can be accessed through a web browser from the control room. In addition, cameras were placed at the side and the back of the room to document the experiment. The students were advised that video recordings took place.

2.2 Methodological Setup

We applied a mixed methods approach with video surveillance, questionnaires, and semi-structured exit interviews to increase validity and to ensure that we uncover the complexity and possible contradictions of the responses from each individual test person. The video feeds allow us to study the immediate responses of the audience.

Questionnaires and interviews allow us to investigate the verbalized responses of the audience, as they describe their experience in their own words. Between the two positions, we used a quantitative section of the questionnaire to probe some suppositions regarding the perceived presence and potential eeriness of the android.



Fig. 1. Geminoid-DK lecturing

3 The Questionnaire

During the second lecture, questionnaires were distributed in the auditorium. From the approximate 150 students present, we collected 127 answer sheets (54 male and 74 female respondents). The questionnaire contains both a qualitative and a quantitative part. In this section, we address the quantitative part. On a scale from 0–10, respondents were asked to rate the following questions, posed in Danish but here translated for the sake of readability.

- a. I had eye contact with the robot
- b. It was as if someone was waiting in the auditorium
- c. I discovered immediately that it was a robot
- d. I thought it was natural that Henrik was talking through the robot
- e. Humanoid robots are scary
- f. The robot is very mechanical
- g. The robot is very human
- h. I think the robot is almost like a human
- i. It seemed natural that the robot was speaking
- j. I was comfortable with the robot lecturing
- k. It is satisfactory to have a robot as a lecturer
- l. The combination of robot, voice, and slides works satisfactory

m. During the lecture I experienced that Henrik was talking to me

n. During the lecture I experienced that the robot was talking to me

The questions were presented in scrambled order, so that for instance question *m* and *n* were not given in consecutive order, but divided by questions *i*, *f*, and *b*. The questions here are divided into four themes:

1. *a-d* reflect the degree of familiarity with the robot in this situation
2. *e-h* reflect the main perception of the geminoid
3. *i-l* evaluates the overall performance of the geminoid
4. *m-n* evaluates the personal perception of the performance of the geminoid

As we have no way of matching anonymous questionnaires with locations in the room, we asked the respondents to rate their proximity to the robot on a scale from 1-5, where 1 is on the front, and 5 is in the back. The proximity obviously affects the perception of the teacher and activities performed by him. Moreover, it is often accepted that placement in large-scale learning rooms reflect engagement and learning style of the learner [10].

3.1 Distribution by Proximity

The radar diagram indicated that answer patterns are roughly the same throughout the zones. But there are of course differences. As we expected, the indicator for eye contact (question *a*) drops rapidly as the distance to the robot increases. There is an unexpected increase from zone 4 to 5, but this can be explained as a statistical invariance based on just two male respondents from zone 5 who gave a score of ten to this question.

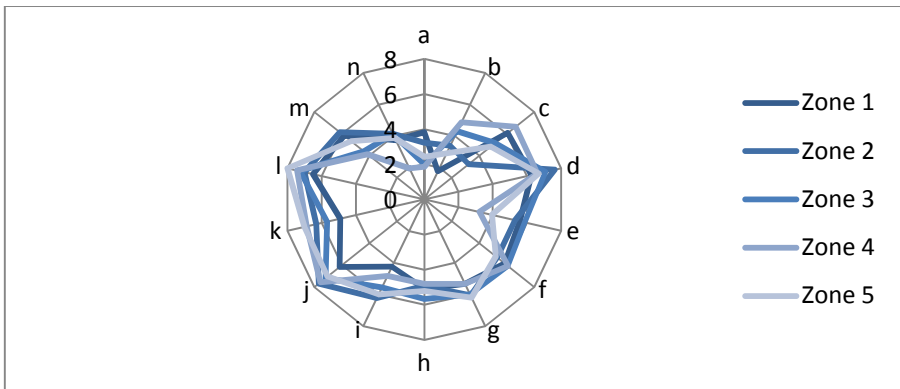


Fig. 2. Radar diagram showing similar answer patterns from the 5 proximity zones

Interestingly, for most questions related to the main perception of the robot (e-h), and of the personal perception of the robot (n-l), the scores from zone 5 are just as high as from zone 1. And there seems to be a tendency that scores from zone 5 are significantly higher than from zone 4. This may of course reflect the reported perceptions of just a few, but it is slightly unexpected.

Respondents from zone 5 give a more positive rating than respondents from zones 3 and 4. The most significant differences in scores that seems to be related to the distance to the robot are seen in *c* and *e*. Concerning *c*: (*I discovered immediately that it was a robot*), the students from zone 4 have the highest score followed by the students from zone 2, 3, 5 and finally zone 1. Surprisingly this indicates that the distance to the robot has no important influence on whether the students immediately perceive the geminoid as a robot.

3.2 Distribution by Gender

Mean values from the questionnaire reveal that male and female responders score the questions fairly similar, with five important exceptions, all having more than one point in difference. On the question of eye contact (question *a*), the female population scores only 1.5 compared to 3.2 among the males. This is a significant difference. Out of the 74 female respondents, only seven rate this question in the upper half of the scale, and they were all seated in proximity zone 1 or 2. In comparison, the 14 of the 54 male respondents rated this question ≥ 5 . And interestingly, they were distributed throughout the auditorium. In fact, 10 of them were sitting in zone 3-5.

The second difference is seen in the responses to question *b*: (*It was as if someone was waiting in the auditorium.*) On average this score is one of the lowest in the questionnaire, but it is significant that the female are less inclined to feel the presence of the geminoid as a feeling of ‘someone’ being in the room. The female score is 3.5 and the male score is 4.6. This could be an indication that females are more sensitive to the robotic presence, and less prone to think of the geminoid as a human presence.

The third and most significant difference between the genders is seen in relation to question *e*: (*humanoid robots are scary*). Here, the females score almost twice as high as the males. This might be a manifestation of The Uncanny Valley, as suggested by Masahiro Mori [9]. There were no differences between the genders in relation to question *c*: (*I discovered immediately that it was a robot*). In fact both males and females had an average score at 5 with a wide distribution of responses between 1 and 10. This means that both among male and female students first impression on whether the geminoid was a robot or a human differed significant. The fact that female students tended to find the geminoid more scaring and that significant less of them had eye contact with the geminoid compared to the male students may indicate that females are more likely to experience The Uncanny Valley than males. However, we have to take into consideration that the answers might reflect some cultural aspects that allow women to express fear, while men may be more reluctant to acknowledge and publicly display these kinds of feelings.

The fourth difference between genders is reflected in question *k*: (*It is satisfactory to have a robot as a lecturer*). Male students have the highest score and the difference is 1.5. This might be an indication that the male students are more fascinated by the robot as a technological device than the female students are.

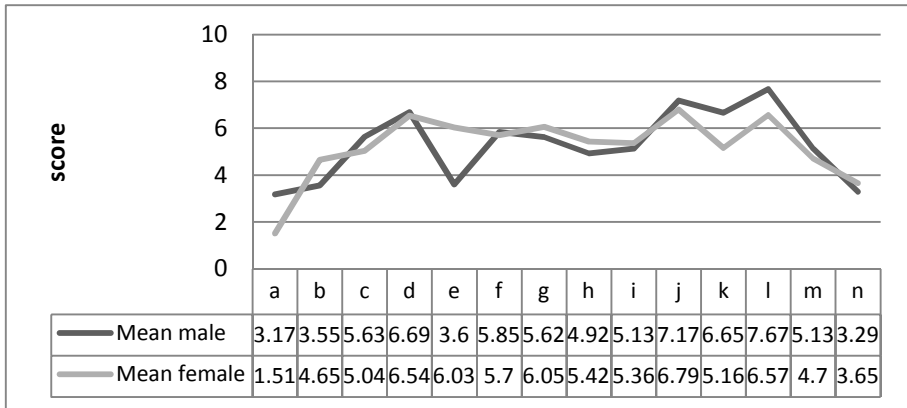


Fig. 3. Distribution by gender

The fifth significant difference between the genders is exposed in question *l*: (*The combination of robot, voice, and slides works satisfactory*). Also in this question the male students have the highest score and the difference is 1.1. The videos confirm that there are no unexpected discrepancies between voice and slides, but there are technical limitations regarding the synchronization of voice and lip movement in the robot. The different scores might indicate that women have higher expectations to the consistency between verbal and non-verbal communication than men, or maybe that women are more prone to find such inconsistencies annoying.

3.3 The Overall Performance and the Main Perception

On the questions related to the overall performance of the robot in this situation (*i-l*), the average scores are fairly high. Both the central question *j* and *l*; (*I was comfortable with the robot lecturing*), and (*the combination of voice, robot and slides works satisfactory*), have a mean rating of 6-7. This result is partly affected by gender, and again we see a higher rating in the zones furthest from the robot. This could indicate that for persons sitting close to the geminoid, special issues apply. A hypothesis could be that discrepancies between voice and lip movement are more important to people in close proximity of the android, whereas this hardly matters for people in the back because they will not be able to distinguish such details anyway.

The highest score among all questions is seen on *l*: (*The combination of robot, voice, and slides works satisfactory*). Taking into consideration that this question does not implicate the respondents' position to the geminoid as being more or less than a tele-operated robot, this might indicate that if perceived more as a medium than as an autonomous feature, the geminoid works satisfactory in correlation with the operator and the slides. Compared with the fact that the average score on question *c*: (*I discovered immediately that it was a robot*), was only 5, we must conclude that it might be difficult to the students to relate unambiguously to the geminoid. This tendency is reinforced in the response to two of the questions related to the main perception of the robot. The scores for statement *f*: (*the robot is very mechanical*), and statement *g*: (*the robot is very human*), are both > 5, indicating that the geminoid

as a phenomenon is so unknown to the students that they cannot place it in relation to their past experiences and their perceptions of the world. In terms of categorization theory, this might indicate an uncertainty as to how the geminoid should be labeled: as a material thing, an almost-human being or an intelligent technological device.

4 Qualitative Questions from the Questionnaires

On the questionnaire the students were asked to fulfill three sentences regarding their impression of Geminoid-DK:

1. I think that Geminoid-DK is....
2. When I saw the robot my first thought was....
3. After having spent some time in the same room as the robot I think....

Concerning question 1 the male students mainly stabled these adjectives on the geminoid: innovative, interesting, exciting, entertaining, genial, functional, human-like and mechanical, and two respondents found it creepy. Several males also stated that the geminoid is 'The Future'. The female students mostly used these adjectives to express what they thought Geminoid-DK was; human-like, impressing, exciting, scary, vivid, authentic and deadpan. For both genders it were average to mention that the geminoid was exciting, but the responds still show a tendency that the male students are more open-minded to or impressed by the technology while the female students make more reflections on whether the geminoid seems vivid and have natural or unnatural expressions.

On question 2, the male students were likely to complete the sentence with questions that indicated that they were wondering if they were exposed to a human or a robot; Is it a man? ... is it technology?... and again their excitement was explicated in statements like; ...This is going to be cool, and This is the future. None of the males expressed that their first thought was that the robot was scary. 1 out of 4 females, though, completed the sentence by claiming that they felt scared, shocked, experiencing an odd man, a staring man, a man making fun with them, and a man making funny movements with his mouth. 8 of the women made comments on the mouth and on the fact that the voice and the movements of the mouth were not in sync. None of the males commented on that, and even though comparatively many females were sitting in the front, we might once again have an indicator that women have higher expectations regarding consistency between verbal and non-verbal cues. One female professed uncannily that: 'It looks like a real man and therefore it is a bit disgusting that he acts like a human'. 1 in 9 female's first thought was that the robot was cool, and again several female stated that the robot looked authentic.

Regarding statement 3 on their thoughts after having spent some time with the robot, most males were still fascinated, but some of them now claimed that something about the robot was not perfected in order to make it appear human-like. A significant number of 26 males found that the geminoid added some value to the lecture or that they got so used to the geminoid that they forgot it was a robot and just focused on the lecture. Several female still found that the geminoid was scary and got disturbed by the discrepancy between voice and mouth.10 females thought that it began to feel natural to be taught by a robot, but 11 claimed that the lecture went impersonal,

trivial, hard to focus on, a joke, monotonous and boring. Only three males stated that the geminoid was inappropriate. They missed the energy and the non-verbal communication from a human lecturer.

It this experiment we found clear indications that males are more open-minded to having a geminoid as a lecturer. A non-gender dependent tendency in the qualitative questions from the questionnaires is that about half the students changed their perception of the geminoid from question 2 to 3. Most of them became more aware of the mechanical features of the robot, some got more used to it and some became either more bored or more fascinated.

5 Exit Interviews

After the lecture five random students were asked to participate in a qualitative semi-structured interview. The responses from the interviews complemented the questionnaires and indicated that the students were trying to fit the geminoid into the prior experiences from their own 'lifeworld' in a Habermasian sense. The following statements indicate the apparent difficulty in making sense of the situation:

- 'You cannot feel it's soul and I think that makes it creepy.'
- 'I thought it was a real person, but it disturbed me that he moved in a creepy way.'
- 'Some of us discussed if he was chewing gum.'
- 'Simon from my group felt that it was really scary. He had apparently been sitting in a place where he had eye contact with it.'
- 'I felt like - either he is about to have an attack or something, and then suddenly I saw - my God - it is a robot.'
- 'I think that the voice blow a little bit of life into the robot, so I am not 100% willing to say that it is just a cold robot.'
- 'People came from behind and asked; why do they take pictures - poor man! They had not understood that it was a robot.'

The respondents had a tendency to switch between referring to the geminoid as 'it' and 'he'. This unsteady use of pronouns is one more indicator that they found it hard to categorize. Trying to explain the geminoid's behavior by placing it into well known situations as gum chewing, heart attacks, and good manners for photographing the students seemed to place the robot into categories that they knew from their everyday life. There are indicators that such a categorization is crucial to the students. One respondent called the geminoid 'a good Disney' and another referred to it as a doll. It is interesting that the categorization issue apparently has a significant impact on the students.

6 Conclusion and Further Research

This experiment has led to the conclusion that the geminoid as lecturers is accepted to some extent, and that there are no significant differences in the answers in respect to proximity, but some gender specific differences have been found. We see a tendency in change of perception of the geminoid during the lecture, but we have found no

consistency in the direction of this change. There are strong indicators that females have higher expectation regarding consistency between the geminoid's verbal and non-verbal communication, and that females more often than males have an experience that might be interpreted as entering The Uncanny Valley. We did not, however, target this issue in our design of investigation, and it would therefore be desirable to look further into this matter to discern whether this bias is specific to the target group under consideration or perhaps applicable in a wider context. Correspondingly, we have found indicators that male students more readily accept having a geminoid as a lecturer, but there are also indicators that categorization issues make a significant impact on the human robot interaction. Specifically:

- Are male students more fascinated of the geminoid as a technological device than female students? And is robot-aided teaching consequently more appropriate to one target group?
- What is the impact of time spent with the geminoid in a learning context?
- Is there a special correlation between proximity and learning style in robot-mediated teaching?

With regard to the gender issues, it is fairly obvious that the gender of the robot might play a role. It would therefore be desirable to repeat the experiment with a female android, equally adapted to the cultural setting.

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